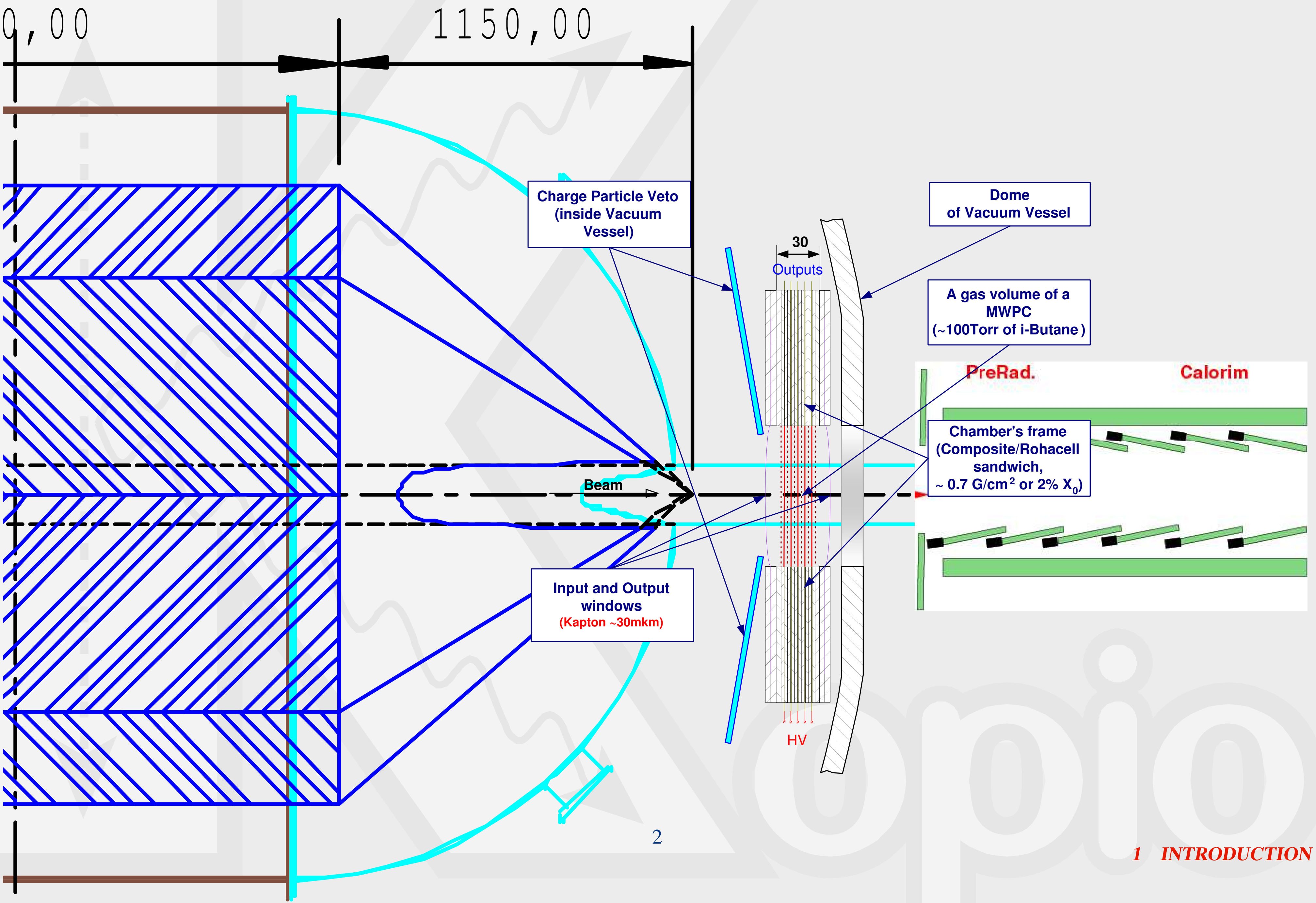
andries van der schaaf

1 Introduction

Scope of subsystem

WBS number	description	costs [a] (kUSD)
1.2.4.1	**Barrel CPV**	1695
1.2.4.2	**Downstream CPV**	956
1.2.4.3	Off-detector Electronics	209
1.2.4.4	Cabling	30
1.2.4.5	Frontend Electronics	714
1.2.4.6	**Beam Chamber System**	539
total		4142

[a] without contingency


0,00
1150,00
Charge Particle Veto (inside Vacuum Vessel)
Dome of Vacuum Vessel
30
Outputs
A gas volume of a MWPC (~100Torr of i-Butane)
PreRad.
Calorim
Chamber's frame (Composite/Rohacell sandwich, ~ 0.7 G/cm² or 2% X0)
Beam
Input and Output windows
(Kapton ~30mkm)
HV

- ***Purpose of CPV:***

veto K_l^0 decay modes with a real or apparent π^0 and a pair of charged particles.

- ***Examples of background modes:***

(i) $K_l^0 \longrightarrow \pi^0\pi^+\pi^-$
(ii) $K_l^0 \longrightarrow \pi^0\pi^\pm e\nu$
(iii) $K_l^0 \longrightarrow \pi^\pm e\nu\gamma$

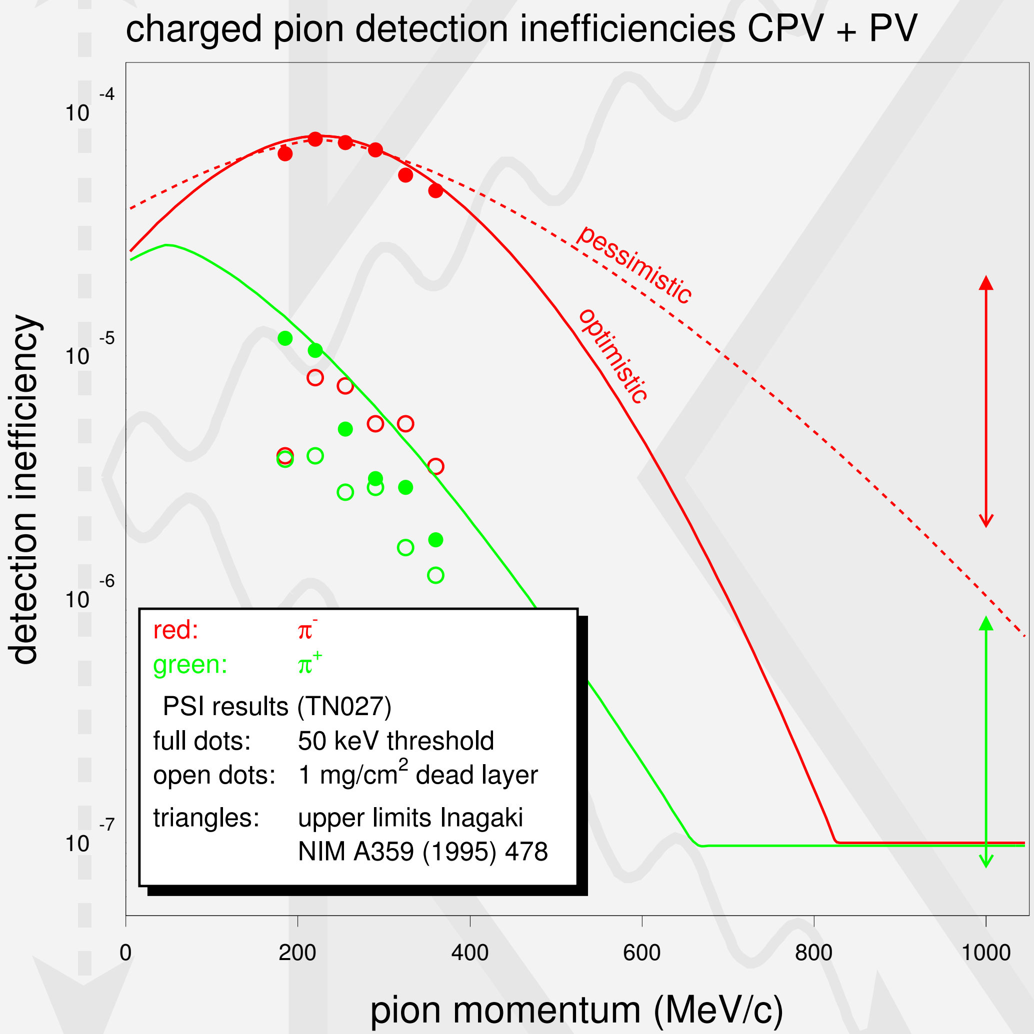
- ***Two intrinsic sources of inefficiency:***

(i) dead layer in front of active medium (π^-, e^+)
(ii) threshold on ΔE signal

- ***Other potential losses:***

(i) non-relativistic particles
(ii) $\pi \longrightarrow \mu$ decay with large "kink"
(iii) veto blindness
(iv) upstream beam hole

2 Goals and Achievements



Pion detection inefficiencies for CPV+PV versus momentum.

Our PSI results are normalized to a
*- **50 keV detection threshold** and*
*- **1 mg/cm^2 dead layer**, corresponding to a coated scintillator.*

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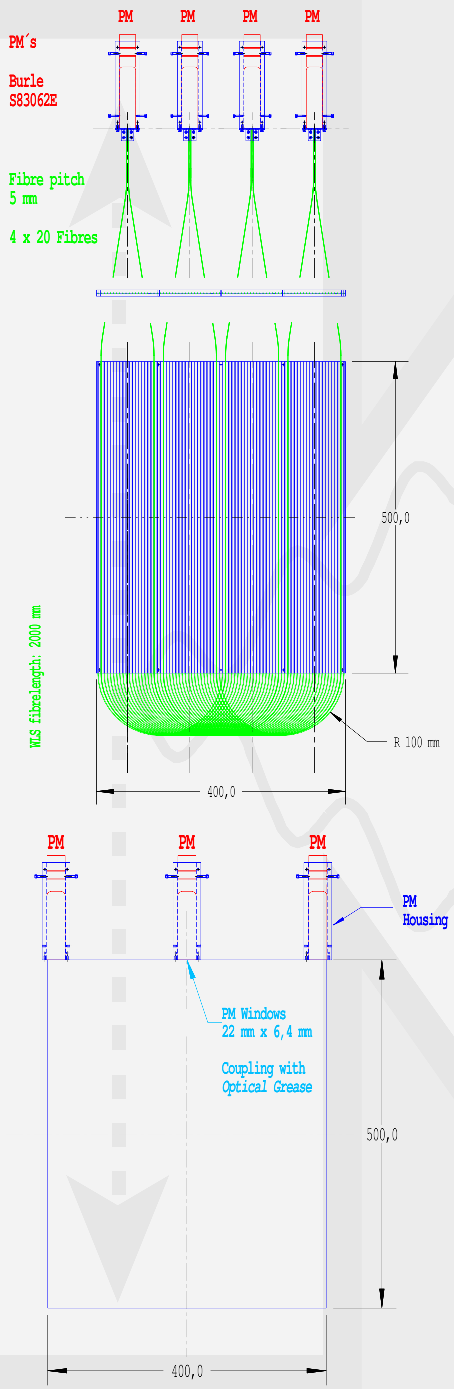
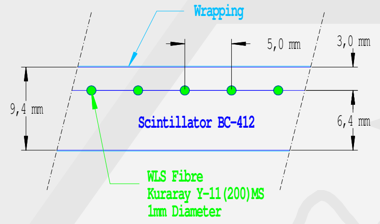




Light yields. Scintillator: BC-412 by BICRON, PMTs: Burle 83062E (Ø 22 mm).

	size [cm²]	thickness [mm]	version		wrapping	nr. of PMT's	p.e.	p.e. in 10 mm
w.l.s. fibers			fiber	geometry				
	20x25	2x6.4	Bicron[a]	straight[c]	Tyvek[d]	4	110	90
		⋮	Kuraray[b]	⋮	⋮	⋮	130	110
	40x50	6.4+3.0	⋮	returning[c]	VM2000[e]	⋮	115	125
direct readout			width of windows	grease				
	20x25	6.4	10 mm	no	black paper	4[f]	130	200
		⋮	⋮	⋮	Tyvek[d]	⋮	260	400
	40x50	⋮	⋮	⋮	⋮	4[g]	130	200
		⋮	22 mm	⋮	⋮	⋮	220	340
		⋮	⋮	yes	⋮	⋮	410	640
		⋮	⋮	⋮	VM2000[e]	⋮	520	810
		3.0	⋮	⋮	⋮	⋮	200	670
		6.4	⋮	⋮	⋮	3[g]	500	**780**
		⋮	⋮	⋮	⋮	2[g]	330	520

[a] BCF-92MC
[b] Y-11(200)MS
[c] read from both ends
[d] DuPont trademark
[e] radiant mirror film produced by 3M
[f] mounted at opposite sides
[g] mounted at one side

Based on these results we propose **40 x 50 x 0.2 cm^3 tiles read with three PMTs**.
This would result in **200-300 modules or 600-900 readout channels.**

3 RSVP Review Status Sheet: WBS No. 1.2.4 Title: "Charged Particle Veto" Date 01/11/05

Preparer/Manager: Andries van der Schaaf

Current Cost Est. (FY05 $M) = 5.70
Assigned Contingency % = 37.6%

Cost Elements (FY05$M): Matls. = 2.53; Effort = 1.61; Ohd. = ee.f; Conting. = 1.56; Total = 5.7

WBS Dictionary Definition:
The Charged Particle Veto System (CPV) has the purpose to recognize K decays with two or more charged particles in the final state which otherwise mimic a signal event. The system contains three components (a fourth component is integrated into the photon veto system inside sweeping magnet D4) situated inside the decay tank and downstream beam pipe:
1)The Barrel CPV consists of plastic scintillator modules surrounding the decay region with the exception of the areas where the beam crosses.
2)The Beam Chamber is a 5-plane low-pressure MWPC covering the downstream hole in the Barrel CPV.
3)The Downstream CPV consists of plastic scintillator modules lining the beam pipe in the region between Beam Chamber and D4. In the case of 2) and 3) it is the combined detection efficiency that has to meet the requirements.

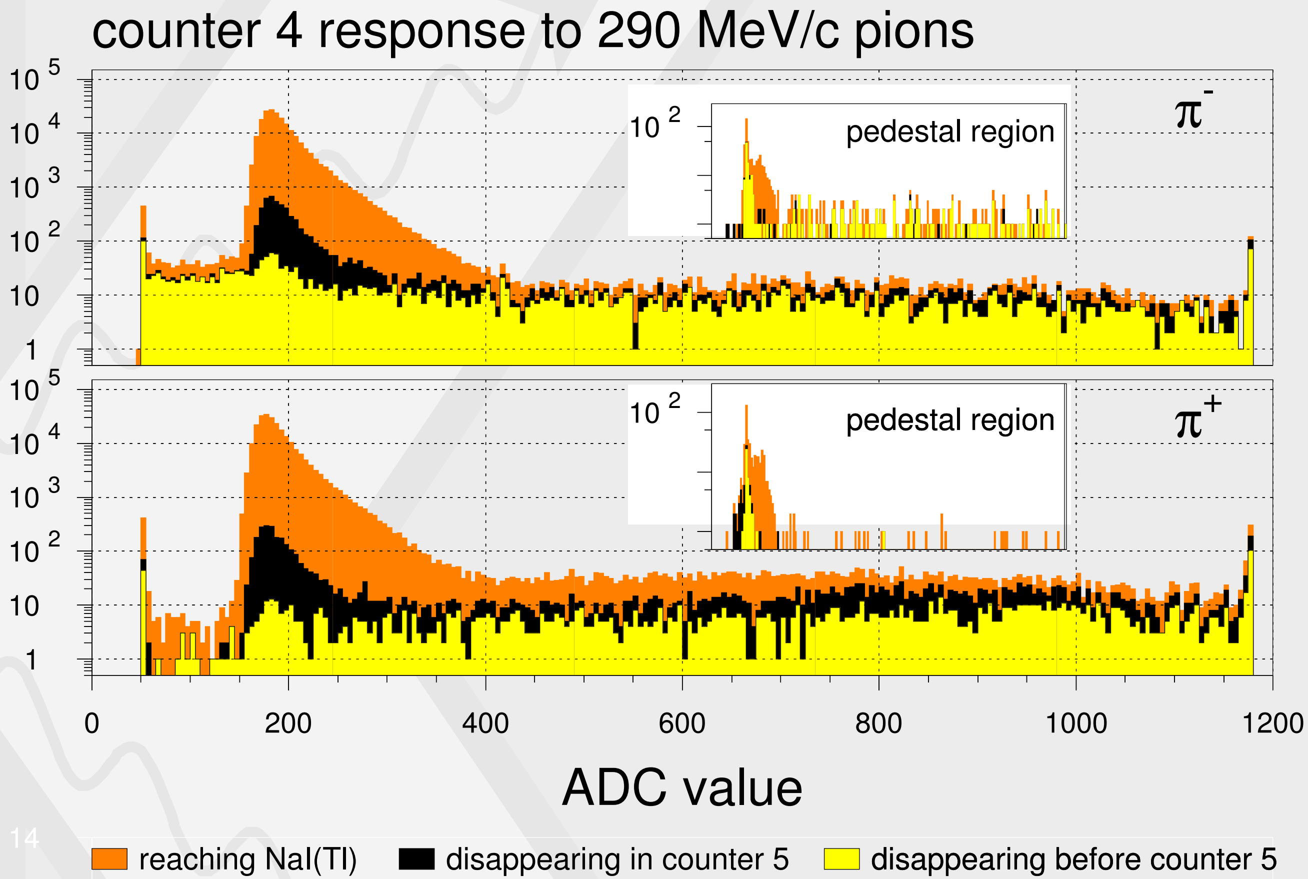
Technical Level of Confidence: Prototype Demonstrated

Basis of the Cost Estimate:	Commercial product	75%	Engineered design	0%
(by percentage of total cost;	Engineered conceptual	15%	Scientist conceptual	10%
sum of fractions = 100%)				

Status of Hardware/Software Development:
1) Prototype built and tested
2) Test chamber built and partially tested
3) Concept defined, to be confirmed by R&D

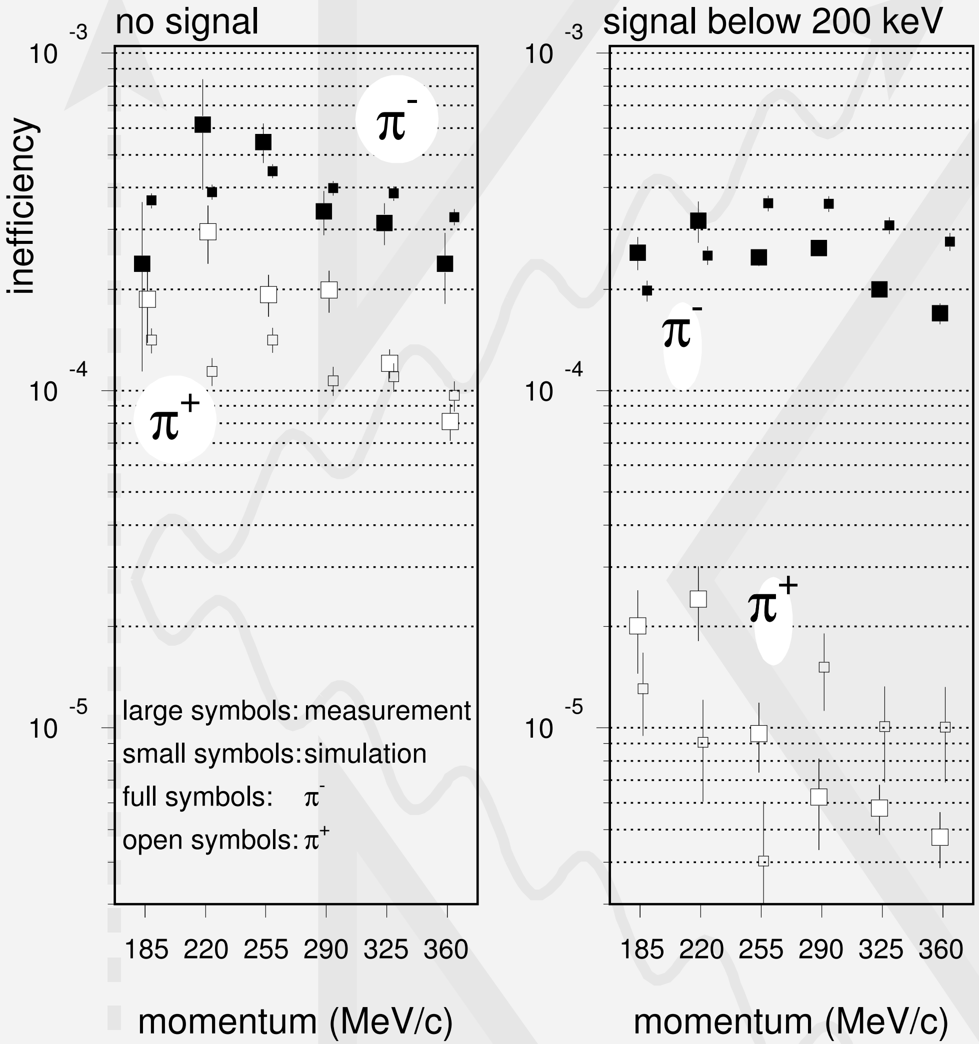
Issues (funding, collaborator shortage, engineering help, etc.):
- Design linked with decay tank
- ≈50% shortage of manpower (mainly physicists)

4 More details

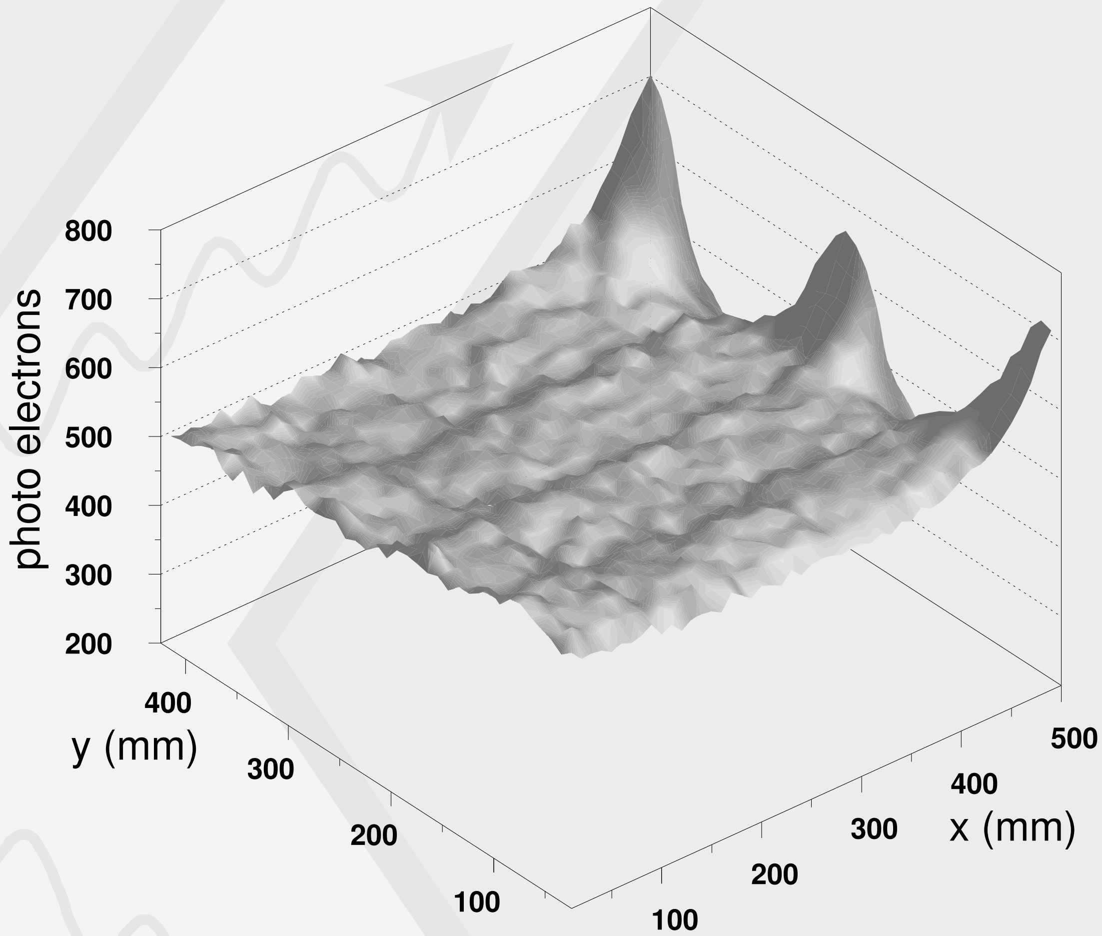


Response of a plastic scintillator to 290-MeV/c $\pi^\pm$ for (i) all events with trajectories pointing at the detector, (ii) the subset of (i) contained in the NaI(Tl) pedestal peak, and (iii) the subset of (ii) contained in the pedestal peak of the second plastic scintillator. The inserts give expanded views of the pedestal region 50<ADC<100.

π detection inefficiencies

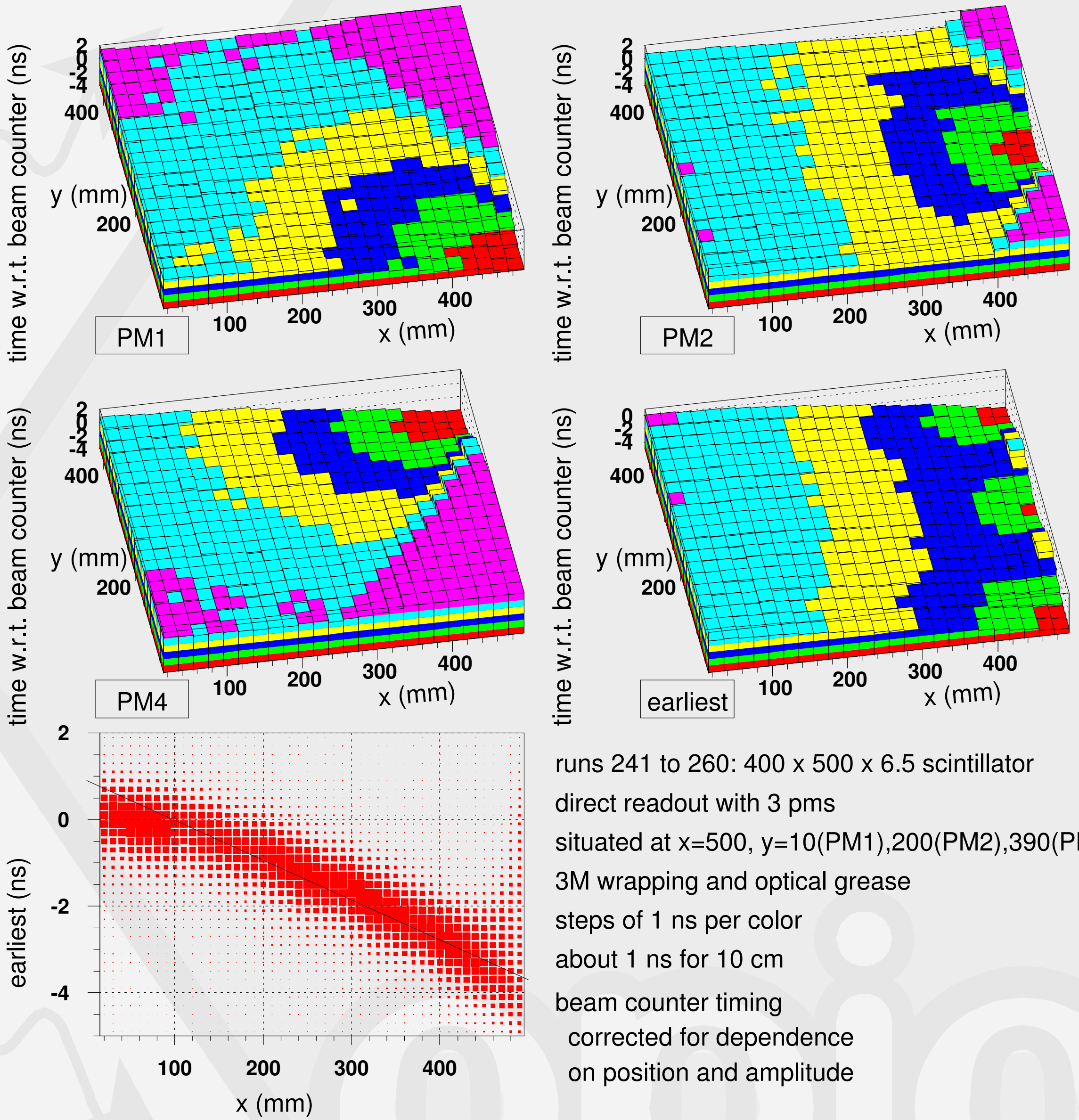


Pion detection inefficiency caused by interactions in the 80-mg/cm^2 dead material between the scintillator and the preceding MWPC, and by a 200-keV detection threshold. These results do not include the additional factor of two for rejection power of the photon calorimeter behind the scintillator.

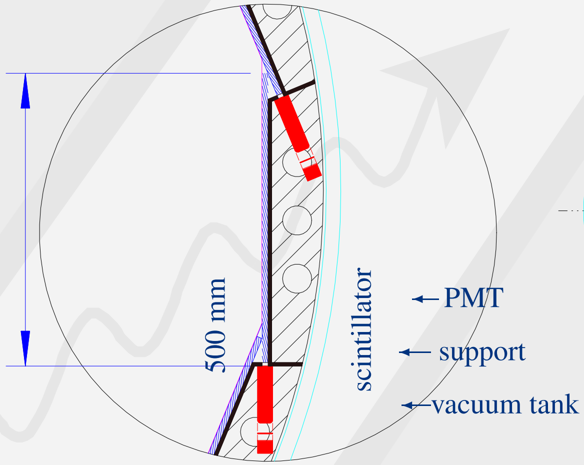


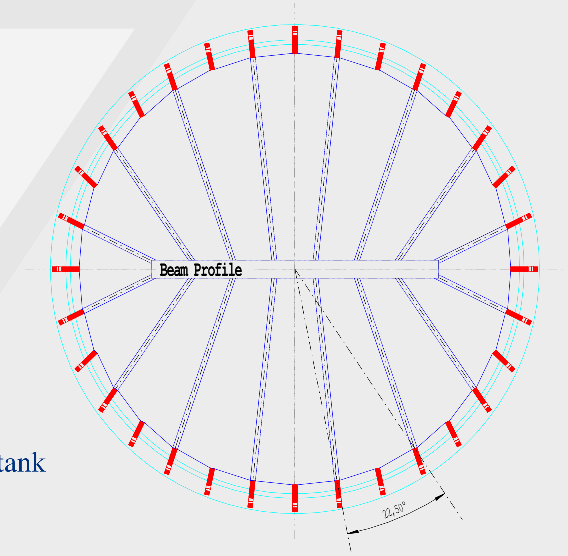
Position dependence of the light yield observed with three photomulipliers coupled directly to the scintillator.

Position dependence of the leading-edge timing from the three photomultpliers, and their total.



runs 241 to 260: 400 x 500 x 6.5 scintillator
direct readout with 3 pms
situated at x=500, y=10(PM1),200(PM2),390(PM4)
3M wrapping and optical grease
steps of 1 ns per color
about 1 ns for 10 cm
beam counter timing
corrected for dependence
on position and amplitude





Current design of the barrel charged-particle veto system.
Left: sector of a cross section perpendicular to the beam.
Along the beam there would be ≈ 10 *modules with overlap to avoid dead space.*
Right: end-cap detectors.

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2.4.1 Barrel CPV

costs in 1000 USD

WBS number	description	material	labor	sum
1.2.4.1	Barrel CPV	910	785	1695

Main costs:

- 50% for modules, mainly light sensors.
  Estimate based on Burle PMT's used so far (USD 600 each), $16(\varphi) \times 10 + 2 + 2(z)$ modularity and three sensors per modules.
  Compromises could be made in all these numbers.
  Less channels would reduce cost of electronics too.

- 20% for vacuum feed throughs

Issues:

- geometry of vacuum chamber

- choice of sensor (PMT $\leftrightarrow$ Geiger APD)

- coating $\leftrightarrow$ wrapping / vacuum foil

- end-cap modularity

2.4.2 Downstream CPV

costs in 1000 USD

WBS number	description	material	labor	sum
1.2.4.2	Downstream CPV	462	494	956

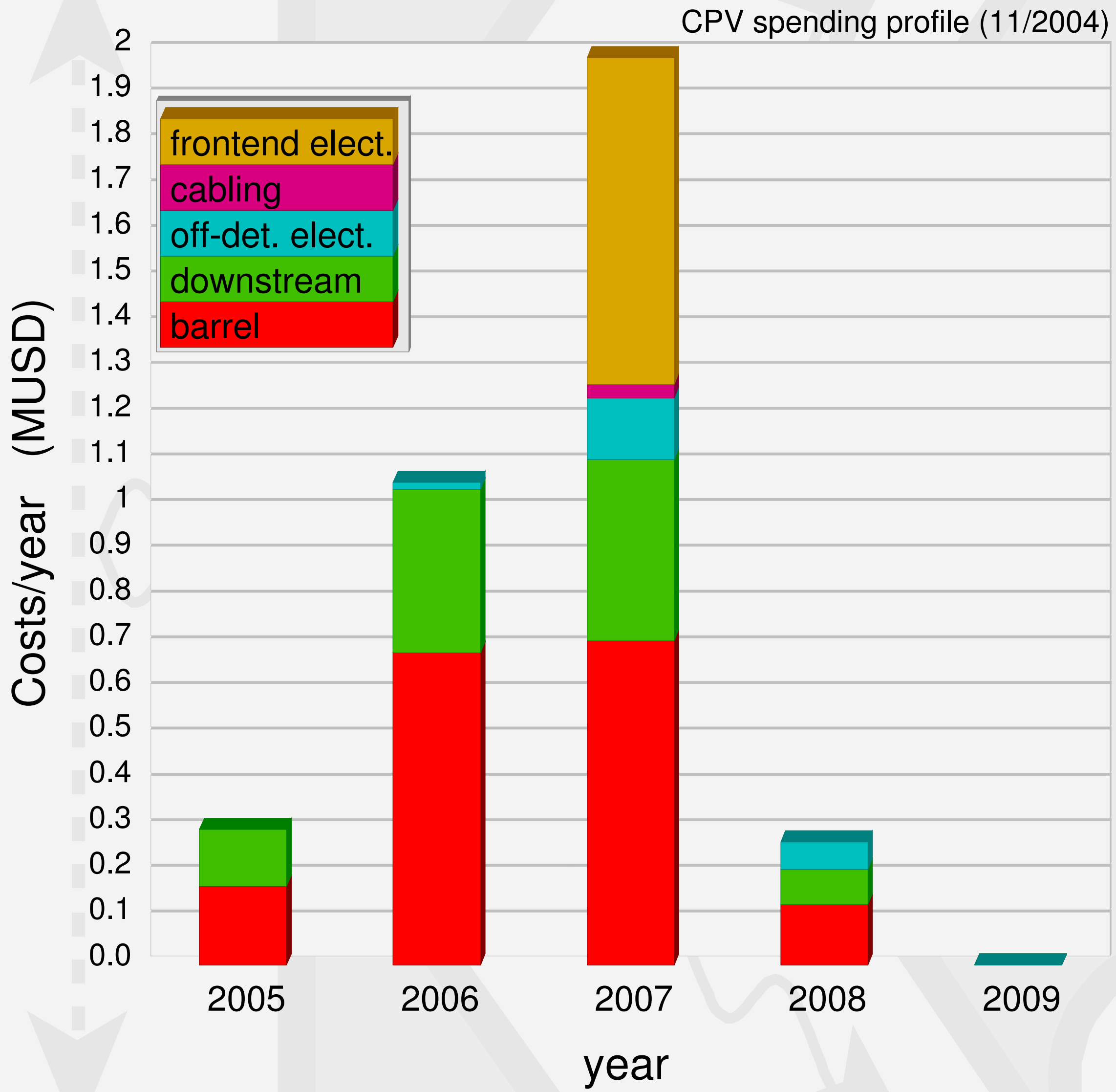
Photo-readout	25%
Integration with vacuum system	20%
Counter material	20%
Design	10%
Assembly of counters	10%
Assembly into structure & installation	10%
Monitoring system, etc.	5%

- How well does Yale MWPC work?
  Efficiency?
  Dead time?
- Does coating work? Who does it?
- one or two layers for downstream CPV?
- choice of photo-detector
- integration with photon veto inside beam pipe
- W.L.S. fibers or GPD readout inside D4?

Cost per readout channel

item	cost USD
PMT	650
on-detector electronics	90
feedthroughs	170
cabling	30
off-detector electronics	210
frontend electronics	715
total	1865

- Half of the CPV costs scale with the number of readout channels, *i.e.* 30% less channels would save 15% costs.
- Readout per module would be 2-3 times more, so the actual detector costs are negligible.
  No need to make compromises there!



MWPC not yet included